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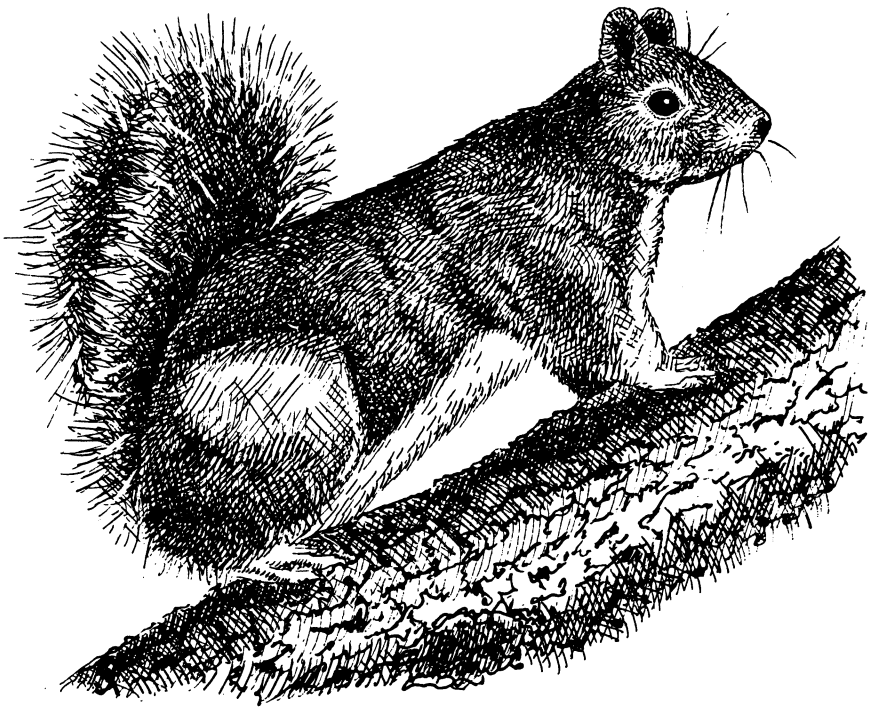
FWS/OBS-82/10.19
JULY 1982

# HABITAT SUITABILITY INDEX MODELS: GRAY SQUIRREL



Fish and Wildlife Service

**U.S. Department of the Interior**

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# HABITAT SUITABILITY INDEX MODELS: GRAY SQUIRREL

by

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# PREFACE

This document is part of the Habitat Suitability Index (HSI) Model Series (FWS/OBS-82/10), which provides habitat information useful for impact assessment and habitat management. Several types of habitat information are provided. The Habitat Use Information Section is largely constrained to those data that can be used to derive quantitative relationships between key environmental variables and habitat suitability. The habitat use information provides the foundation for HSI models that follow. In addition, this same information may be useful in the development of other models more appropriate to specific assessment or evaluation needs.

The HSI Model Section documents a habitat model and information pertinent to its application. The model synthesizes the habitat use information into a framework appropriate for field application and is scaled to produce an index value between 0.0 (unsuitable habitat) and 1.0 (optimum habitat). The application information includes descriptions of the geographic ranges and seasonal application of the model, its current verification status, and a listing of model variables with recommended measurement techniques for each variable.

In essence, the model presented herein is a hypothesis of species-habitat relationships and not a statement of proven cause and effect relationships. Results of model performance tests, when available, are referenced. However, models that have demonstrated reliability in specific situations may prove unreliable in others. For this reason, feedback is encouraged from users of this model concerning improvements and other suggestions that may increase the utility and effectiveness of this habitat-based approach to fish and wildlife planning. Please send suggestions to:

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CONTENTS

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# GRAY SQUIRREL (Sciurus carolinensis)

## HABITAT USE INFORMATION

### General

The gray squirrel (Sciurus carolinensis)inhabits hardwood and mixed hardwood-coniferous forests (Uhlig 1955; Golley 1962). Although they may occur in a variety of forested habitat types, large, densely forested areas are preferred (Taylor 1974).

### Food

Fruits, floral parts, buds, bark, roots, fungi, and animal matter are seasonally important foods for the gray squirrel (U.S. Forest Service 1971). The annual diet of the gray squirrel in Missouri included 97 plant and 47 animal foods (Korschgen 1981). Eighteen of the plant items contributed 86.8% of the total food volume. Mast was the principle food item during the winter months. Hickories (Carya spp.), pecan (C. illinoensis), black walnut (Juglans nigra), and red mulberry (Morus rubra) were used to a much greater extent than indicated by their percentage of the forest composition. Hickory mast was selected most often by squirrels in Ohio (Nixon et al. 1968).

A significant relationship existed between the annual seed crop and subsequent squirrel densities in an Ohio study (Nixon et al. 1975). The survival of summer-born juvenile squirrels was drastically reduced when the seed crop fell below 145.7 kg of sound seed per ha (130 lb/acres), because of the increased competition for mast from older individuals and other wildlife species. A mast production greater than 168 kg/ha (150 lb/acres) is needed to sustain reasonably high squirrel densities. Approximately 8.5 $m^2$ (71.8 $ft^2$) of basal area in trees of seed producing size [≥ 25.4 cm (10 in)] will produce this amount of seed.

A variety of mast producing species should be present over a range of sites in order to minimize the effect of crop failure (Nixon et al. 1975). Mast crops vary by species, age of tree, soil and weather influences and seed production by individual trees (Spurr and Barnes 1980). Weather is unlikely to have a major impact on seed production in a forest that contains several tree species because the time of flowering will vary by species.

Large, dominant trees with exposed, sunlit crowns are the primary seed producers in closed stands (Spurr and Barnes 1980). Smaller trees with shaded crowns will produce few, if any, seeds.

Cover types. This model is intended to evaluate gray squirrel habitat in the following cover types (terminology follows that of U.S. Fish and Wildlife Service 1981): Deciduous Forest (DF) and Deciduous Forested Wetland (DFW).

Minimum habitat area. Minimum habitat area is defined as the minimum amount of contiguous habitat that is required before an area will be occupied by a species. The mean minimum home range for the gray squirrel is at least 0.49 ha (1.2 acres). For purposes of this model, it is assumed that a habitat of less than 0.4 ha (1 acre) will provide no suitability; the HSI will equal 0.0 in such areas.

Verification level. This model was reviewed by F. S. Barkalow, North Carolina State University, and C. M. Nixon, Illinois Institute of Natural Resources. Improvements suggested by these reviewers were incorporated into this model.

## Model Description

Overview. All habitat requirements of the gray squirrel can be satisfied within deciduous forests or deciduous forested wetlands. Therefore, this model treats the gray squirrel as using only these cover types, and habitat evaluation based on this model only considers the quality of life requisites provided by deciduous forested cover types. The cover and reproductive needs of the gray squirrel are assumed to be identical. It also is assumed that the availability of water will never be more limiting than the winter food or cover/reproduction potential of the site.

The following sections document the logic and assumptions used to translate habitat information for the gray squirrel to the variables and equations used in the HSI model. Specifically, these sections cover: (1) identification of variables used in the model; (2) definition and justification of the suitability levels of each variable; and (3) description of the assumed relationships between variables.

Figure 1 illustrates the relationships of habitat variables, life requisites, and cover types for the gray squirrel.

Winter food component. A wide variety of vegetative food is consumed by the gray squirrel during the spring and summer. The late summer, fall, and winter diet consists mainly of hickory, beech, and oak mast. It is assumed that the availability of fall and winter food will always be more critical than the availability of spring and summer food. Mixed forest stands will provide a more stable winter food supply than stands that consist of only one mast producing species. A forest stand should have at least 8.5 $m^2$ per hectare (36 $ft^2$/acre) of basal area of seed producing trees [$\geq$ 25.4 cm (10 inches) dbh]. It is assumed that the optimum density of mast trees is between 40 to 60% canopy closure. When tree canopy closure is greater than 60% mast quality and quantity decreases because tree crowns are shaded by adjacent trees.

Winter food quality is a function of the density and species diversity of mast producing trees of the proper size in the stand. Habitats which lack trees that produce hard mast will have no winter food for gray squirrels.

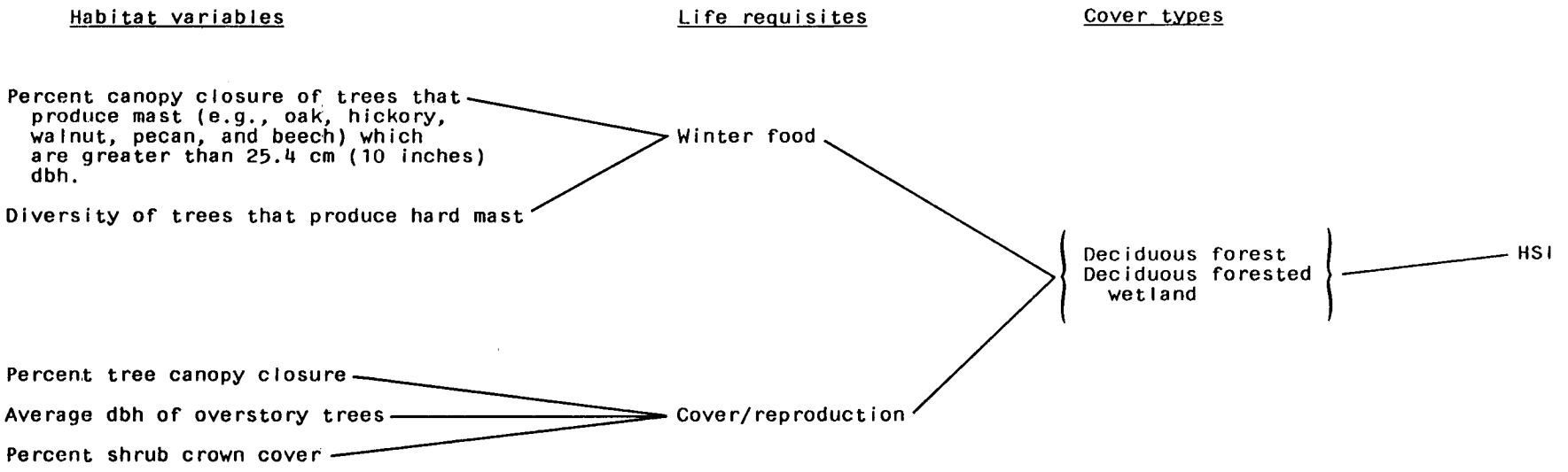



Figure 1. Relationship of habitat variables, life requisites, and cover types in the gray squirrel HSI model.

Species diversity in a forest contributes to a stable food supply. Optimum conditions are assumed to exist when the forest stand contains at least four species of trees that produce hard mast.

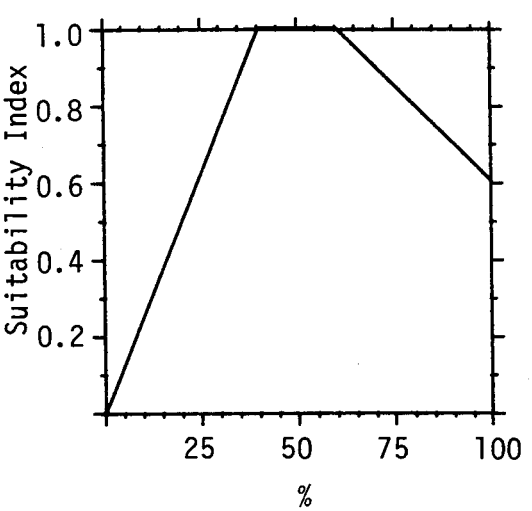
Cover/reproduction component. Dense forest stands that have overstory trees with large diameter, and a moderately dense understory provide optimum cover for gray squirrels. Gray squirrels are almost entirely dependent on tree cavities for winter cover and litter rearing. Forest stands dominated by mature to overmature trees are assumed to contain enough cavities to meet the cover requirements of the gray squirrel. Optimum conditions are believed to occur when tree canopy closure ranges from 40 to 75% and the average dbh of overstory trees is at least 38.1 cm (15 inches). Overstory trees with an average dbh of 12.7 cm (5 inches) or less indicate a forest stand that is too young to contain the cavities required by gray squirrels.

The density of shrubby understory vegetation in a forest will influence the cover/reproduction value for gray squirrels. Optimum understory shrub crown cover is assumed to range from 20 to 30%. Forest stands that do not have a shrub understory will be of slightly less value than stands with optimum shrub density. When shrub density increases above 30%, the cover/reproduction value of the stand will decrease, regardless of the percent closure or size of overstory trees. It is assumed that, although understory shrub density may greatly reduce the value of a stand value as gray squirrel cover/reproduction habitat, it will never completely limit the ability of the stand to provide cover.

## Model Relationships

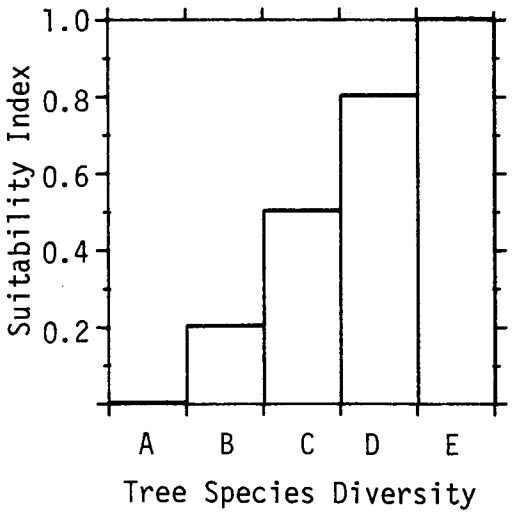
Suitability Index (SI) graphs for habitat variables. This section contains suitability index graphs that illustrate the habitat relationships described in the previous section.

| Cover type | Variable | |
|---|---|---|
| DF,DFW | $V_1$ | Percent canopy closure of trees that produce hard mast (e.g., oak, hickory, walnut, pecan, and beech) which are ≥ 25.4 cm (10 inches) dbh. |

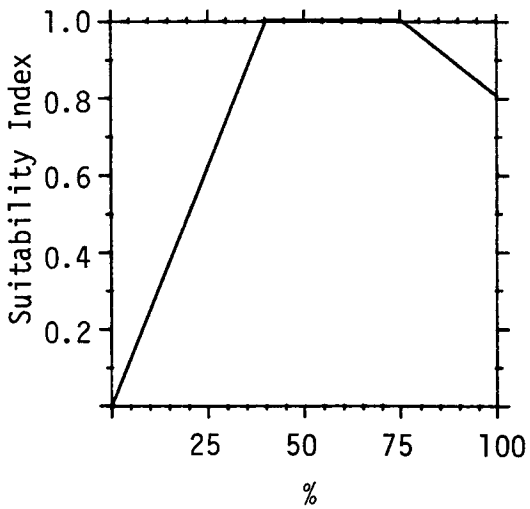


DF,DFW $V_2$ Diversity of tree species that produce hard mast.

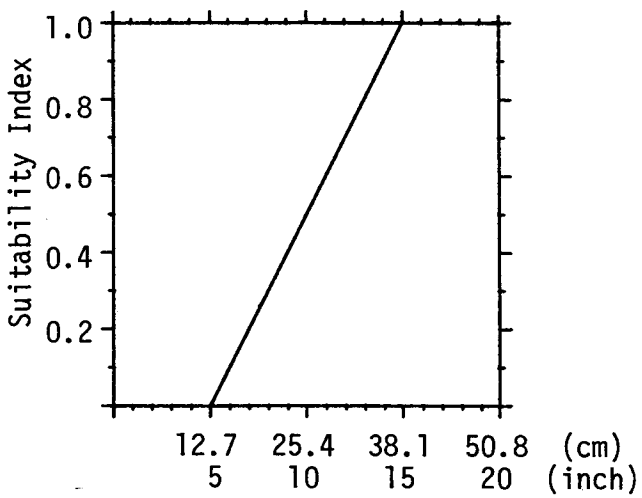
A) None present
B) 1 species present
C) 2 species present
D) 3 species present
E) 4 or more species present



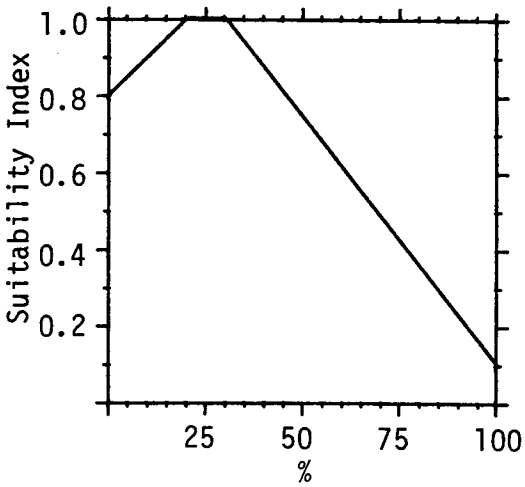

DF,DFW $V_3$ Percent tree canopy closure.




DF,DFW $V_4$ Average dbh of overstory trees.



| | | |
|---|---|---|
| DF,DFW | $V_5$ | Percent shrub crown cover. |




Equations. In order to obtain life requisite values for the gray squirrel, the SI values for appropriate variables must be combined through the use of equations. A discussion and explanation of the assumed relationships between variables was included under Model Description, and the specific equations in this model were chosen to mimic these perceived biological relationships as closely as possible. The suggested equations for obtaining life requisite values for the gray squirrel are presented Figure 2.

| Life Requisite | Cover Type | Equations |
|---|---|---|
| Winter food | DF,DFW | $(V_1 \times V_2)^{1/2}$ |
| Cover/reproduction | DF,DFW | $(V_3 \times V_4)^{1/2} \times V_5$ |

Figure 2. Equations for determining life requisite values by cover type for the gray squirrel.

HSI determination. The HSI for the gray squirrel will equal the lowest of the values obtained for Winter Food or Cover/reproduction.

## Application of the Model

Definitions of variables and suggested field measurement techniques (Hays et al. 1981) are presented in Figure 3.

| Variable (definition) | | Cover types | Suggested technique |
|---|---|---|---|
| $V_1$ | Percent canopy closure of trees that produce hard mast (e.g., oak, hickory, walnut, pecan, and beech) which are ≥ 25.4 cm (10 inches) dbh [the percent of the ground that is shaded by a vertical projection of the canopies of trees which produce a hard shelled fruit and have a dbh of at least 25.4 cm (10 inches)]. | DF,DFW | Calculated area of plant using crown diameter on strip quadrat |
| $V_2$ | Diversity of tree species that produce hard mast (the number of tree species present in the stand or sample site that produce hard mast). | DF,DFW | Transect, tally |
| $V_3$ | Percent tree canopy closure [the percent of the ground surface that is shaded by a vertical projection of the canopies of all woody vegetation > 5.0 m (16.5 ft) tall]. | DF,DFW | Transect, line intercept, remote sensing |
| $V_4$ | Average dbh of overstory trees [the average diameter at breast height (1.4 m; 4.5 ft) above the ground of those trees that are ≥ 80 percent of the height of the tallest tree in the stand]. | DF,DFW | Cruise for tallest tree, sample with optical range finder and Biltmore stick on strip quadrat |
| $V_5$ | Percent shrub crown cover [the percent of the ground surface that is shaded by a vertical projection of the canopies of woody vegetation < 5 m (16.5 ft) tall]. | DF,DFW | Transect, line intercept |

Figure 3. Definitions of variables and suggested measurement techniques.

## SOURCES OF OTHER MODELS

No other habitat models for the gray squirrel were located.

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Habitat preferences and species characteristics of the gray squirrel (Sciurus carolinensis) are described in this publication. It is one of a series of Habitat Suitability Index (HSI) models and was developed through an analysis of available scientific data on the species-habitat requirements of the gray squirrel. Habitat use information is presented in a review of the literature, followed by the development of a HSI model. The model is presented in three formats: graphic, word, and mathematical. Suitability index graphs quantify the species-habitat relationship. These data are then synthesized into a model which is designed to provide information for use in impact assessment and habitat management activities.

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Animal ecology
Habitability
Mathematical models
Mammals
Squirrels

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Habitat requirements
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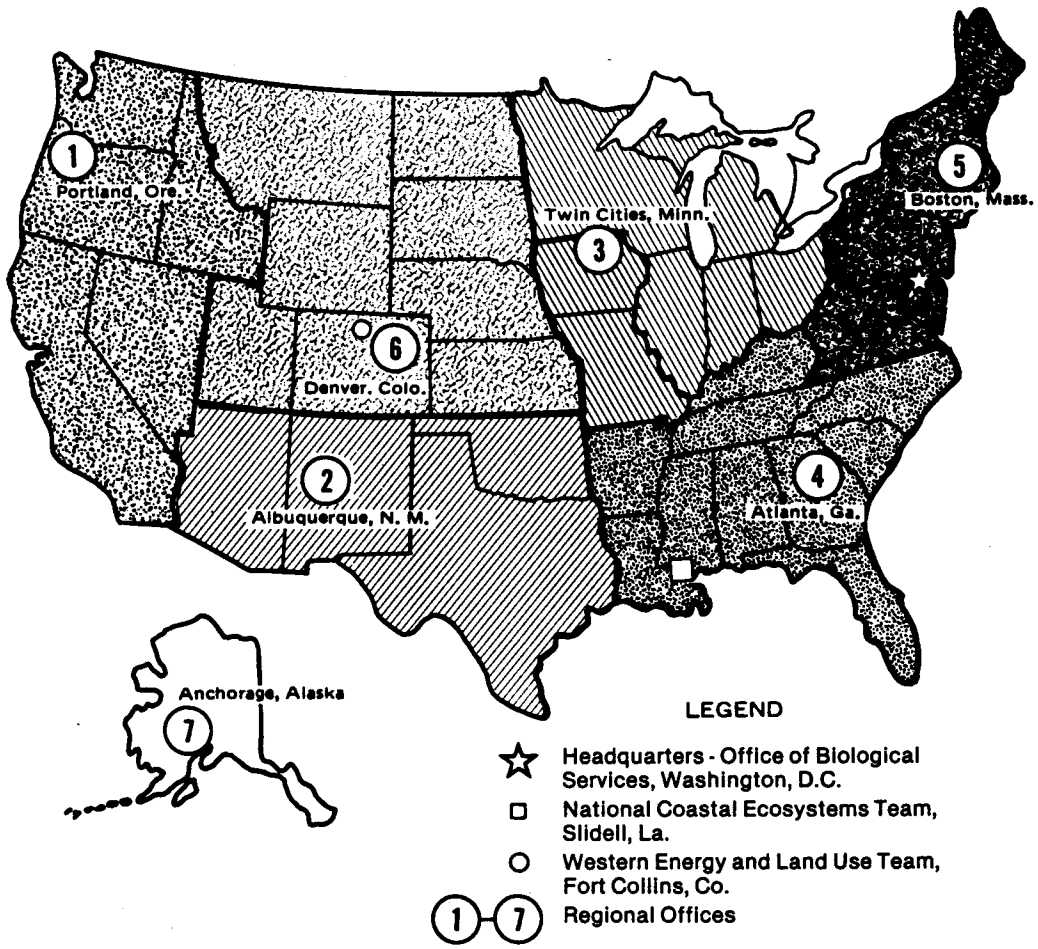


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